BATTLE LABS: TOOLS AND SCOPE

Julian Cothran

The Battle Lab is a tool for the rapid insertion of new technology into weapons systems and for the early evaluation of potential military components and experimental systems. It can yield cost savings to project managers and system users. It is multi-faceted, meeting such diverse requirements of the acquisition process as the engineering test beds used by the project manager and the simulations used by commanders, planners and others for wargaming. This paper describes the desired integration of battle labs with test beds, and how test beds produce: a) the required fidelity of input for Battle Lab demonstrations; and, b) experiments with evolving technological advancements.

According to General Fredrick M. Franks, Jr., former commander of the U.S. Army Training and Doctrine Command (TRADOC):

> (W)hat we wanted to do in TRADOC was provide ourselves a means—given resource constraints—to take emerging ideas from recent battlefield experiences such as Just Cause and Desert Storm and continue to experiment with those ideas and with technology insertions that could be applied to furthering our warfighting capabilities using simulations as well as some actual prototype (hardware) systems tied in with the simulations (Roos and Franks, 1992).

This can be accomplished by "networking simulators that offer a safe, cost effective environment augmenting live field exercises; one in which we can afford to exercise all the components of today's combined arms teams," according to George T. Singley, III (Singley, 1993). Singley adds:

> (M)aterial developers will shorten acquisition time while reducing both costs and development risks by employing Distributed Interactive Simulation (DIS) during concept definition, concept exploration, design, MANPRINT assess-

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **1996**	2. REPORT TYPE	3. DATES COVERED **00-00-1996 to 00-00-1996**
4. TITLE AND SUBTITLE **Battle Labs: Tools and Scope**		5a. CONTRACT NUMBER
		5b. GRANT NUMBER
		5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER
		5e. TASK NUMBER
		5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Army Missile Command,Forward Area Air Defense Project Office,Hunstville,AL,35808**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES **Acquisition Review Quarterly-Winter 1996**		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**12**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

ments and prototyping.

Simulation also allows for quicker, more effective trade-off studies. The result is clearer requirements in less time and at lower cost (Franks and Ross, 1993; Slear, 1992).

Gen. Franks and General Jimmy D. Ross, former commander of the Army Materiel Command (AMC), agreed that:

> Battle Labs' requirements for rapid insertion of new technologies into systems via components and experimental systems will be tested iteratively, demonstrated and evaluated for military value. To a much greater degree than in the past, this process is based on simulation of both the physical system and its battlefield performance. Battle Labs provide a means for the Army's systematical examination of war-fighting ideas and evaluation of the options offered by new technical capabilities (Franks and Ross, 1993).

They went on to say that,

> (T)he objective of each Battle Lab is to determine the potential military value offered by a new capability as early as possible. Products of these efforts typically are software models or early stage 'austere prototypes' such as 'breadboards' or 'brassboards' without the full functionality of complete fieldable systems or components. Testing is likely informal and may involve an iterative model-fix-model or test-fix-test cycle.

This means of virtual prototyping not only facilitates concurrent engineering but also encourages continuous, comprehensive evaluation by the combat development, material development, and test and evaluation communities at the beginning of the acquisition process—when the weapon system is being designed to reduce the time and cost of the acquisition cycle (Ross, 1993; Singley, 1993).

In summary, the PM must develop test bed tools and integrate his efforts with the Battle Labs if he is to demonstrate system capabilities that are not only measurable, but also result in the high fidelity simulations that will streamline the acquisition process. Battle Labs, the Louisiana Maneuvers (LAM), and the methodology of DIS combine nicely to point the way, but the proof is in the implementation. Problems encountered in implementing the concept and methodologies of simulation frequently involve the misperceptions of decision makers. Among these is the widely shared misperception that

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testing must deliver sensational, 'crash and burn' results to be deemed effective by the public. This erroneous expectation must give way to a desire for the in-depth, structured testing and analyses performed in a test bed and Battle Lab environment. That new environment truly provides the qualitative and quantitative data about a weapon system's added value that will support program and system decisions.

Another misperception lies within the systems engineering process. Although the steps in the process are good, how and when these steps are executed is not unalterable, and the perception that they are is mistaken. This is pivotal to the success of Battle Labs.

To implement simulation properly requires a teaming of the user (or combat developer) and the Project Manager (or material developer). The aim of their combined efforts reflects a concurrent engineering philosophy that provides direct feedback into the weapon system development cycle. The goal is to use modeling and simulation to test, evaluate, and further amplify any number of factors in that cycle. Among these: Operational Requirement Document (ORD) requirements, smart technology insertion, comparison of alternative evolutionary concepts, predictions of the system's functional and operational performance, design and development of new devices and algorithms, system integration, system software support, command and control, best doctrinal way to fight the system, and MANPRINT issues. These assessment and development needs are not new; however, that they are obtained as a joint team effort is new.

The Battle Labs concept, with specified centers controlled by the combat developer, is well-understood. Unfortunately, the contribution of the test bed to the Project Manager's team is less visible, as is the interplay of test bed data used by combat developers and material developers. Nevertheless, a fusion of the test beds and battle labs, providing end-to-end simulations and simulators, would foster rapid prototyping through 'hardware-in-the-loop' (HWIL). It would also combine, in a DIS synthetic environment, the domains of research, development and acquisition (RD&A), military operations, and training (see Figure 1).

...the widely-shared misperception that testing must deliver sensational, 'crash and burn' results...

Project managers own the detailed simulations (or test beds) that provide accurate weapon system performance data to wargaming models. These complex test beds place soldiers in detailed simulations of hardware prototypes and new system software to assess the weapon's warfighting 'value added.' Through DIS, test beds enable a new weapon system, or a new configuration of an old weapon system, to interact in a war game in real time. The combat developer is given access to the simulation at his home station. This is the Battle Lab concept enabled through a teaming of users, PMs, contractors, and developers.

Whether test beds support the required evaluation areas and address the widest scope of issues (while remain-

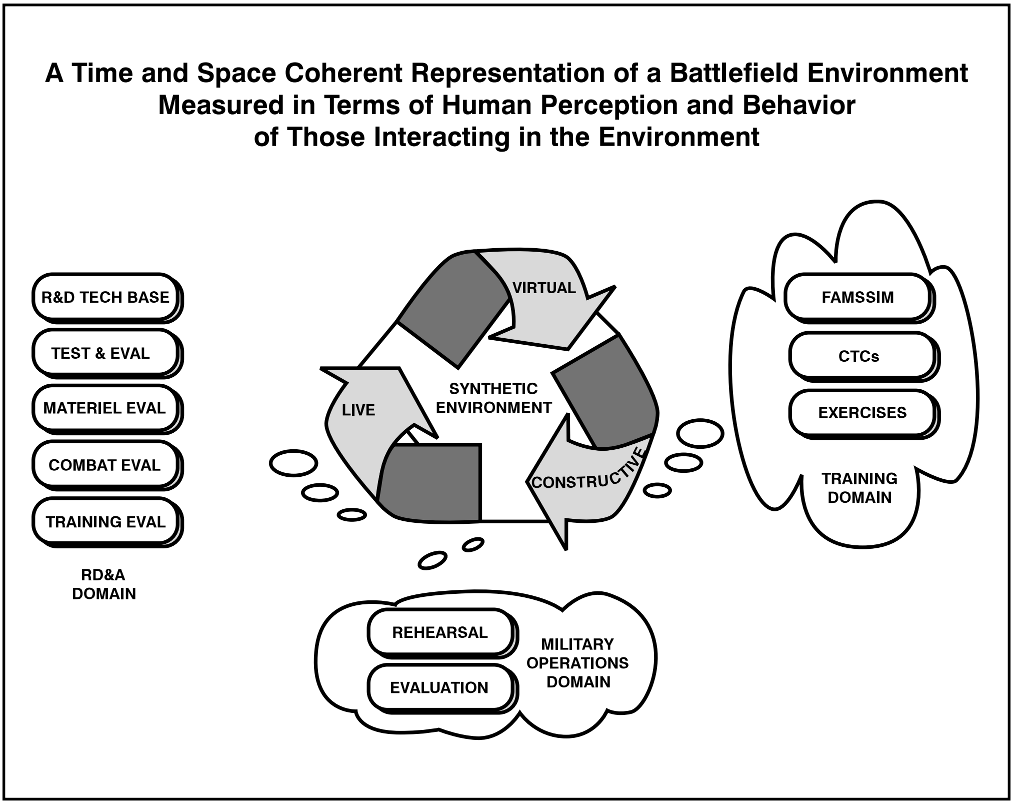

Figure 1. DIS Synthetic Environment

ing flexible and comparatively inexpensive) should be asked in determining exactly what types and combinations of simulations, test beds, and tests are needed. This evaluation is illustrated in Figures 2 and 3.

EVALUATION AREAS

The next step is to assess whether the detail and scope of the evaluation methodology will support technical requirements generation and evaluation, operational requirements, and overall requirements (e.g., force modernization). The assessment of these applications is shown in Figure 4, as applied to the STINGER/AVENGER, the Forward Area Air Defense (FAAD) Project Office, and the Weapon System Management Directorate (WSMD). Next we assess the scope and detail of the tools [missile simulation (HWIL); weapon system fire unit simulation (HWIL); Software in the Loop, (or SWIL); and Man in the Loop, (or MIL), and the battlefield models], and how these tools interact with each other within the DIS virtual network. This is illustrated in Figure 5 as an integrated evaluation and Test Evaluation Master Plan (TEMP) asset.

ANALYSIS CHARACTERISTICS	EVALUATION METHODS		
	SIM	TEST	ANAL.
SCOPE (RANGE OF ISSUES)	WIDE	MED	WIDE
EXPECTED COSTS	MED	HIGH	LO
FLEXIBILITY	HIGH	LO	MED
FIDELITY	MED	HIGH	LO
CONTROLABILITY	HIGH	LO	HIGH
IMPACT	HIGH	HIGH	LO

BEST GOOD POOR

Figure 2. System Evaluation Methodology Trade-Off

		SYS. ARCH. TRADES	COMPONENT DESIGN	COMPONENT EVAL.	SYSTEM INTEG.	SYS. EVAL. (PA)
SIMULATION	TEST BED	X	X	X	X	X
	ENG. MODELS (EX. - MSL. 6-DOF)		X	X		
	ENGAGEMENT SIM. (BEWSS)	X	X	X		X
TEST	BENCH TESTS			X		
	SYS. ENG. TESTS (DEM / VAL)			X	X	
	OPERATIONAL				X	X

LEGEND:
SYS - SYSTEM
ARCH - ARCHITECTURE
EVAL - EVALUATION
INTEG - INTEGRATION
PA - PERFORMANCE
EX - EXAMPLE
MSL - MISSILE
DOF - DEGREE OF FREEDOM
SIM - SIMULATION
DEM - DEMONSTRATION
VAL - VALUATION

Figure 3. Evaluation Areas

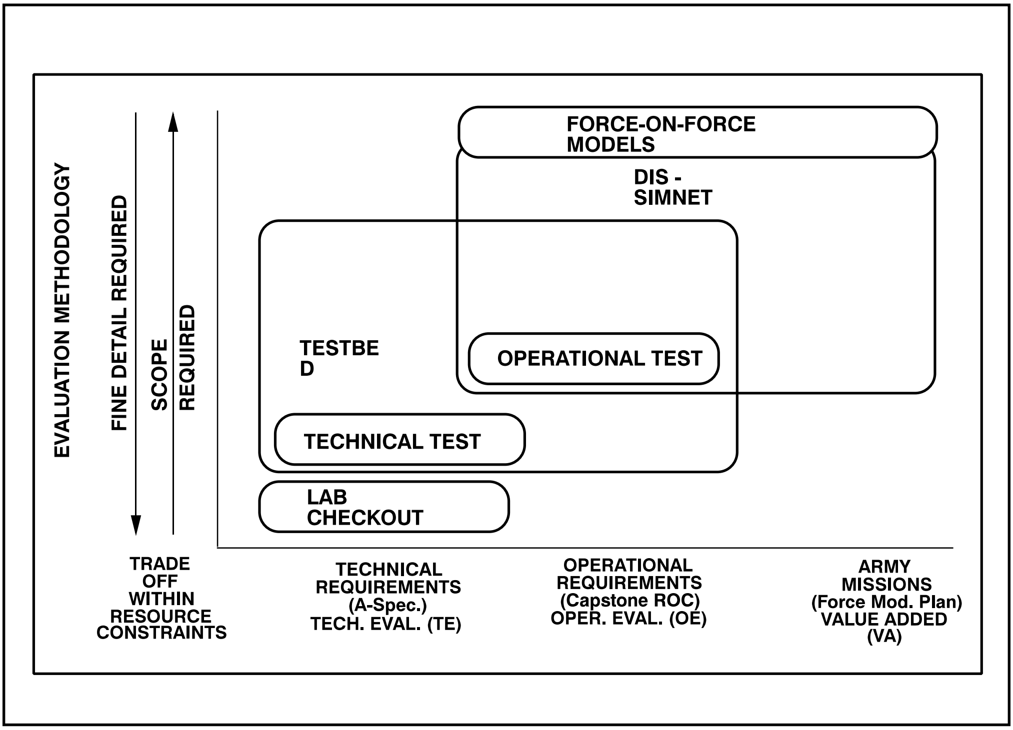

Figure 4. FAADS Simulation Test Bed, System Evaluation Methodologies/Applications

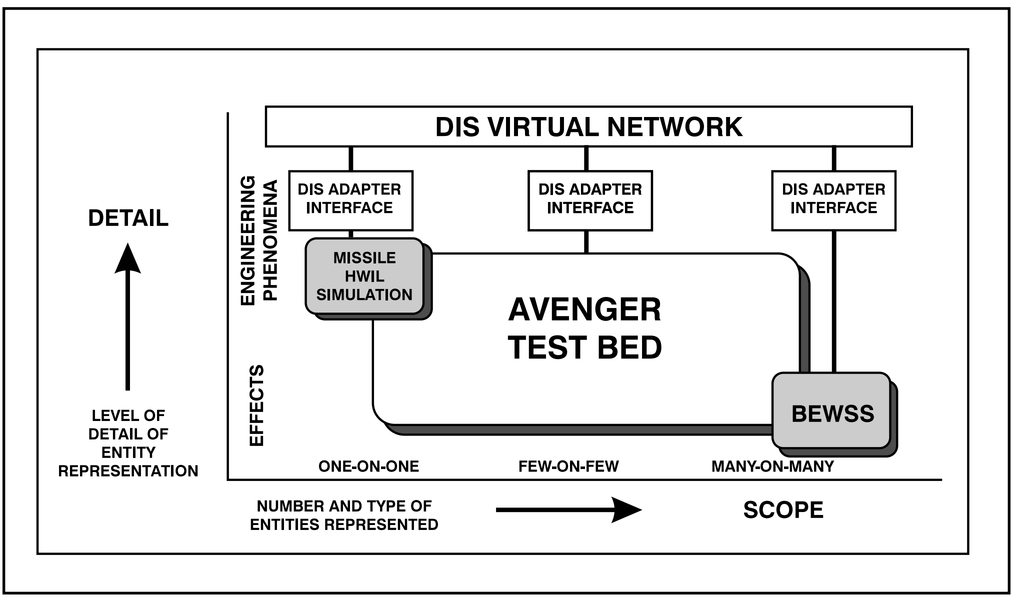

Figure 5. Scope, Detail, and Interaction

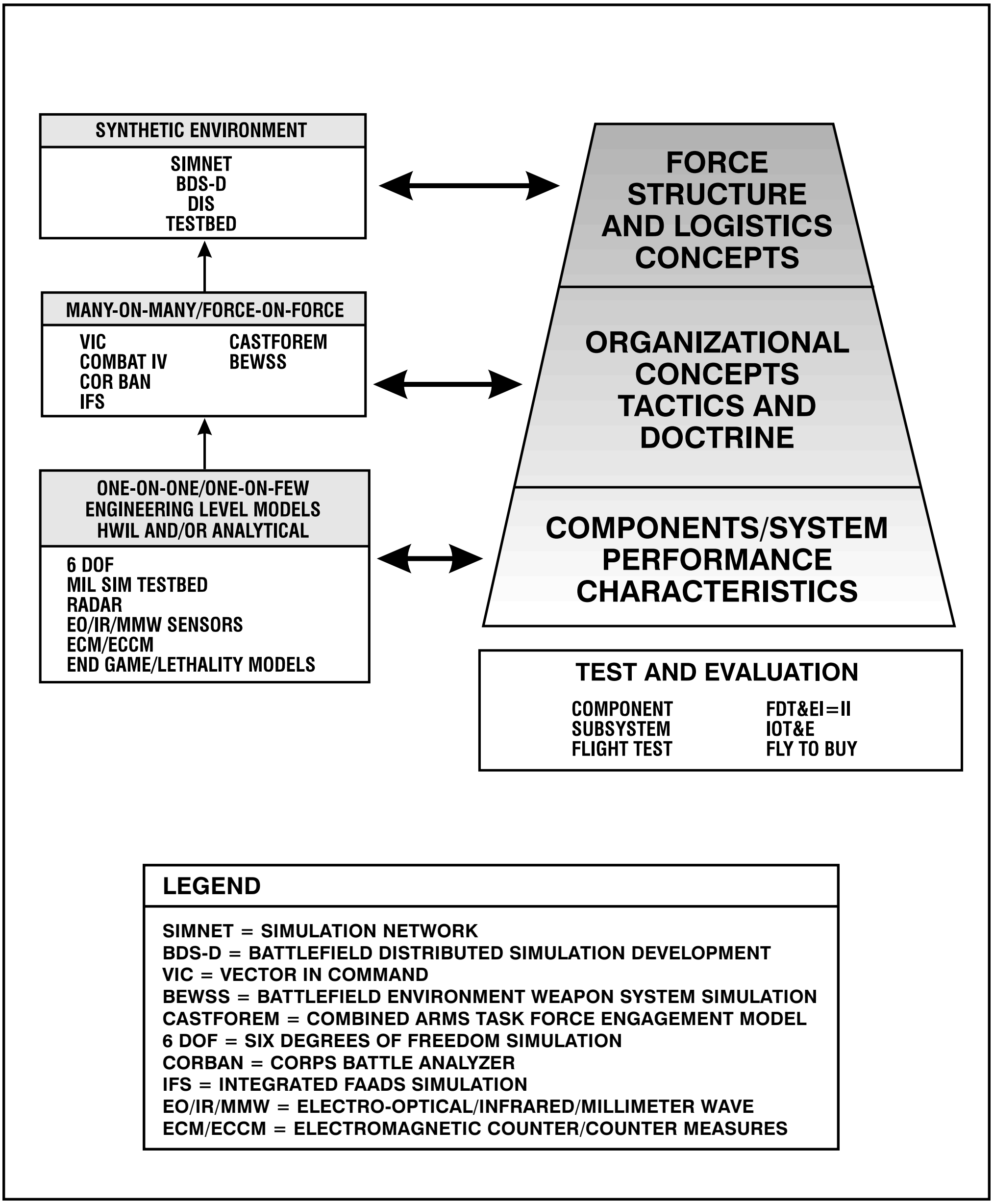

Figure 6. Simulation Hierarchy (PM's Tool Kit)

After determining the detail and scope required of the test bed, simulations and models, an ordering by type and function needs to be performed to produce a simulation hierarchy. This type of hierarchy is shown in Figure 6 for the FAAD PM and WSMD. The next assessment determines how and when the various tools will be needed, and how they should connect (see Fig-

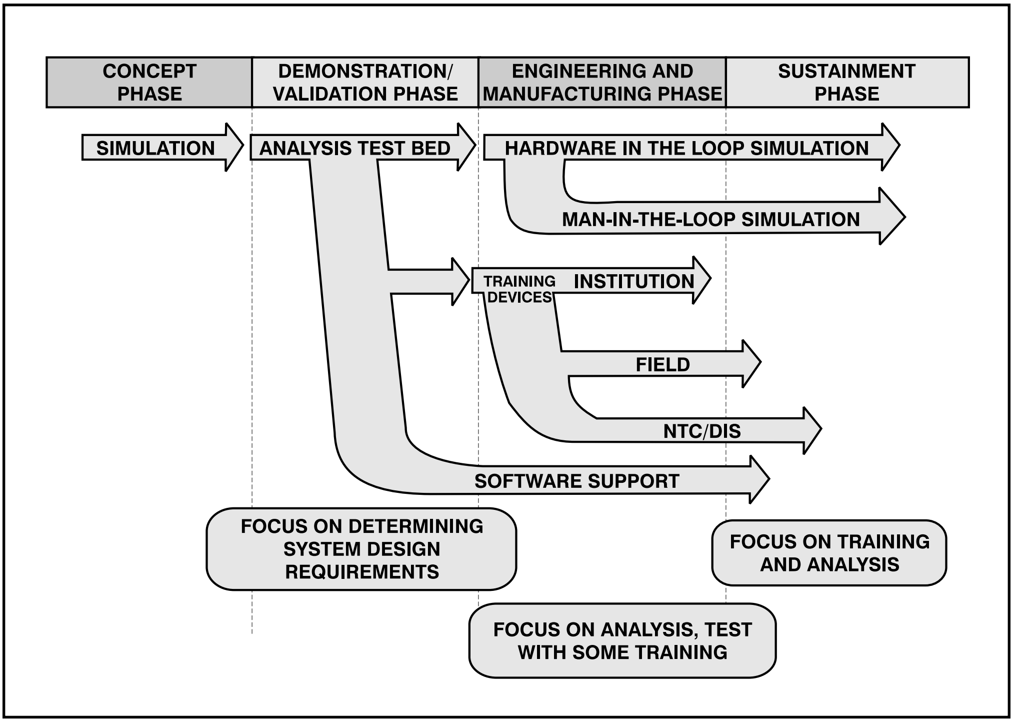

Figure 7. Simulation Evolution/Life Cycle

ure 7). Within this evolution, the simulated weapon system prototypes are evaluated by soldiers. This process of virtual prototyping produces the benefits seen in Figure 8.

The Air Defense Program Executive Officer (PEO) completed an initial review of the library of battlefield models in 1989. He concluded that no existing model could provide all of the features needed and desired for analyses of Forward Area Air Defense (FAAD) systems. Instead, it would be necessary to use several models in support of system performance assessments, tactics, and doctrine analyses. The survey identified minimum requirements for models and defined criteria for evaluating and comparing models. A subsequent evaluation of each model's applicability and utility for analyzing FAAD issues was also conducted. This revealed that the models would have to be capable of supporting battalion-sized or larger units in an asymmetric play of forces (e.g., Blue tactics by Blue, Red tactics by Red). The models would also have to be in use at present in the simulation community.

The CASTFOREM, JANUS(T), and VIC models were chosen; together, the three models satisfied the battlefield integration issues. Many of the detailed outputs from the interactive JANUS(T) could be fed into CASTFOREM. Similarly, some of the battalion and brigade-level results from

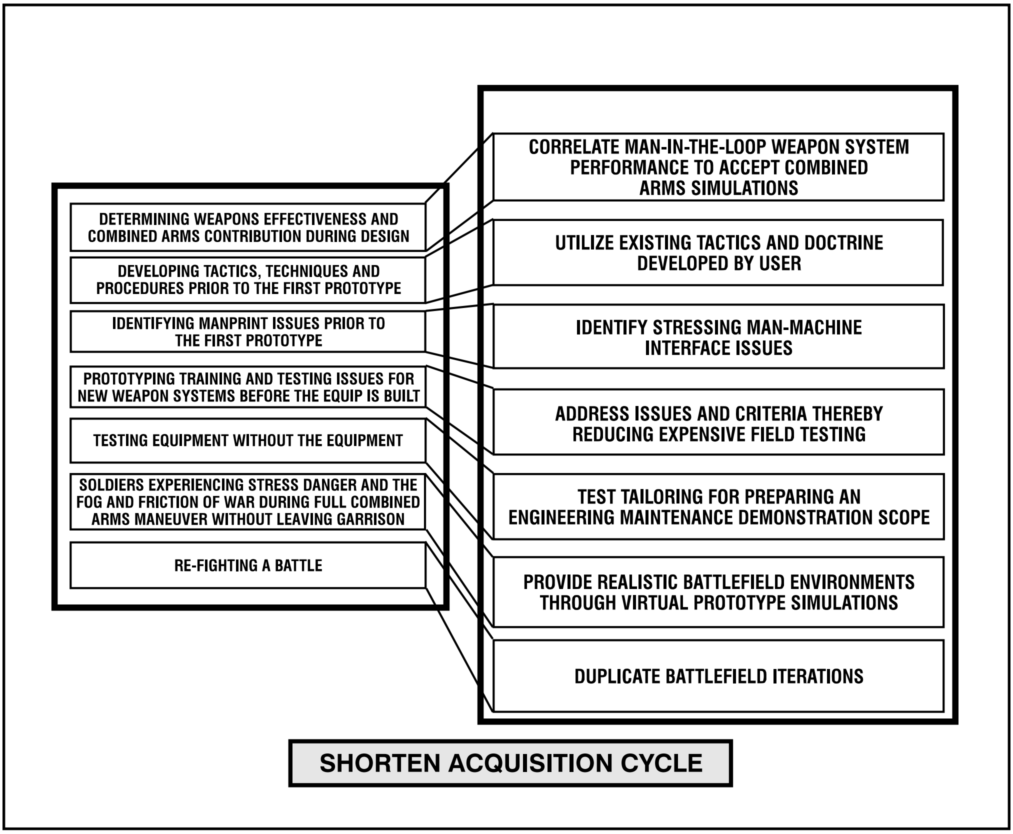

Figure 8. Virtual Prototype Simulation - Life Cycle

CASTFOREM could be used as input for the corps and division-level VIC simulation (Air Defense PEO, 1989). Yet all three had major drawbacks: They assumed perfect identification of friend or foe (IFF); they modeled command and control logic through decision tables only, thus not allowing for assessment of a C3I capability on the battlefield; they lacked detail in the play of fixed-wing aircraft; they excluded fratricide; they allowed no explicit electronic warfare play; and they used unchanging weather parameters. In addition, JANUS(T) provided only a very coarse level of modeling for a fire unit by assuming perfect targeting by the threat (Red) aircraft, an 'a priori' knowledge of Blue's location by Red aircraft, and visual identification ranges for Blue forces applicable to tanks rather than the detection, recognition, and identification ranges common to sensors in Air Defense units. Nevertheless, these limitations of the models make a test bed attractive since their outputs, when inserted into the VIC battle, can easily provide the correct inputs for a CASTFOREM or VIC model, or any upgrade of these with higher resolution and fidelity.

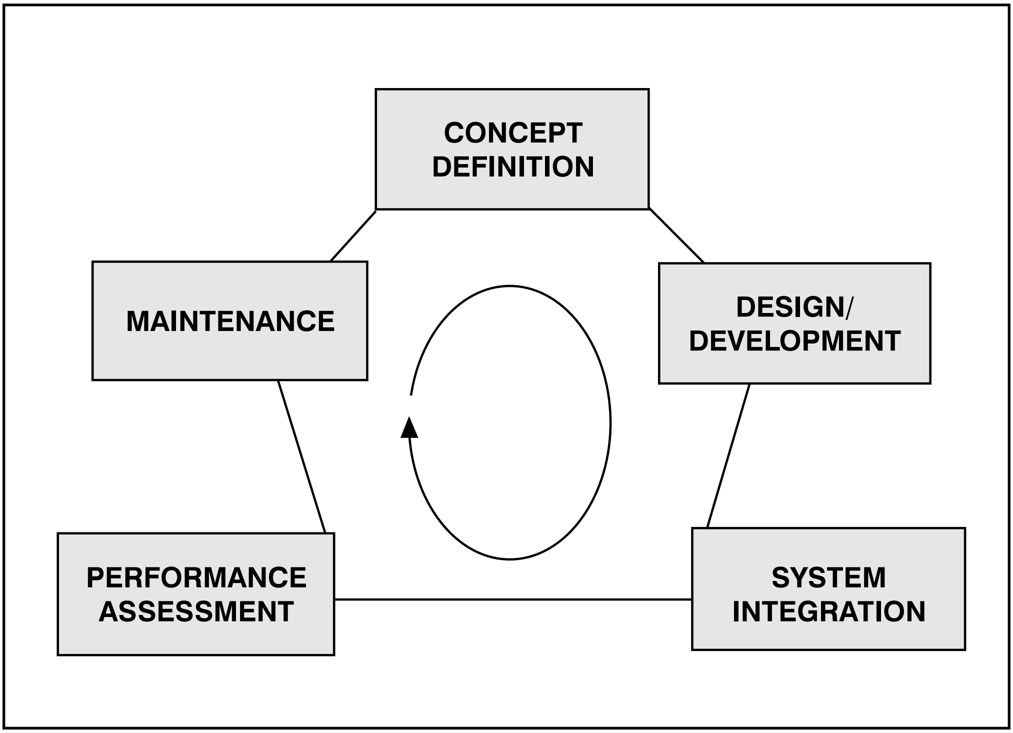

Figure 9. Test Bed Applications

THE UTILITY OF IMPLEMENTATION

Within the constraints of the preceding section, the test bed is an analysis tool emulating the weapon system and used to conduct experiments, studies and analyses to support: a) predictions of the system's functional and operational performance; b) comparison of alternative evolutionary concepts; c) design and development of new concepts, devices and algorithms; d) system integration; and e) maintenance and support of system software (AVENGER Project Office, 1992) (see Figure 9).

A wide variety of concept and configuration trades-offs are necessary in any system's evolutionary development. This use of test beds is manifested at several levels. At one level, the test bed allows investigation into alternative structures for weapon systems or relationships between system components (e.g., the effects of system modularization, element intercommunication, and centralization of decision making). Another level of test bed use is the selection of alternative weapon system elements (i.e., technology insertion) based on comparisons of their effectiveness. A third level of test bed utility lies in measuring variations in a significant component's characteristics and how they impact the effectiveness of the full system. These three levels of analyses provide the basis for informed decisions on trade-offs.

Test beds also support component design and development. The test bed is used to shake down preliminary designs (i.e., analytical models), evaluating them in the context of weapon system objects and functions. This enables the subsystem to be studied in a controlled but realistic operational environment for which the design variables serve as study parameters. It also allows other elements of the system to influence modification and evaluation of the design, as well as permitting observation of the effects of design parameters on system performance.

Design and development of components and subsystems are brought together in system integration. The test bed has tremendous utility for reducing the high risk in this area. System integration issues explored on the test bed include functional or operational coordination, completeness, and integrity; system interface validation; data fusion; and the cooperative operation of system elements. The test bed may also serve to identify and quantify any problems in functional or data interface and to investigate alternative solutions for such problems, and also serve to support experiments or demonstrations of system integration concepts.

Performance assessment of a weapon system is another use of the test bed, as is validation of engagement simulations or wargaming models. The test bed can generate data invaluable in validating engagement models by demonstrating the system's fully integrated operational functions under full engagement scenarios. Using the test bed to predict the results of a weapon system's field and firing tests supports pre-test planning and post-test analyses, reduces the amount of real world testing required, saves time and money, and provides results that are more constructive and defensible.

In today's software driven weapon systems, the test bed is a necessary complement to the normal software development environment. The test bed provides the complex and realistic stimuli and operational states necessary to determine the adequacy of the weapon system's operational, imbedded software.

Summary

The Test Bed and Tools for DIS are ready and functional. Integration and consolidation of efforts to utilize these tools must be continued. Many resources and simulations are untapped that can help the Project Managers and the user. The Program Executive Officer and TRADOC User communities need to synchronize their efforts to create cost effective weapons systems and system improvements through robust simulations.

REFERENCES

Air Defense Program Executive Officer (PEO). (1989). Appendix A: Simulation Model Survey. *Forward Area Air Defense System Simulation Plan*, (Report MA89-PEO-AD-0001), Feb. 17. Author.

AVENGER Project Office. (1992). *System Specification for the AVENGER Simulation Test Bed (Draft)*, July. Author.

Franks, Gen. F.M., Jr. and Ross, Gen. J.D. (1993). *How To Do Business With Battle Labs - A Guide For Industry*. Washington: Army Materiel Command.

Ross, Gen. J.D. (1993). Legacy for '90s in Louisiana Maneuvers. *Army*, June.

Roos, J.G. (1992). An Exclusive AFJI Interview With: General Frederick M. Franks, Jr., USA, Commanding General, US Army Training & Doctrine Command (TRADOC). *Armed Forces Journal International*, October.

Singley III, G.T. (1993). Distributed Interactive Simulation-A Preview. *Army Research, Development and Acquisition Bulletin*, March-April.

Slear, T. (1992). Battle Labs: Maintaining the Edge. *National Defense*, November.